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**Drainage and Flooding
Assessment
Commercial Office and Hotel
Tower Development, 88 Walker
Street and 77-81 Berry Street
North Sydney
Eastmark Holdings Pty Ltd**

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Appendix A

Existing Stormwater Culvert Diversions Option Report

1. Executive Summary

General

This report forms part of the Environmental Assessment (EA) requirements regarding Drainage and Flooding for the proposed Commercial Office and Hotel Tower development, 88 Walker Street and 77-81 Berry Street, North Sydney as outlined by the Director-General's requirements.

The development at 88 Walker Street is a proposed 20 level hotel and the development at 77-81 Berry Street will integrate the existing tower with a separate multi-storey tower. This will include basement car parking and retail shopping.

Existing perimeter street drainage infrastructure will be retained whilst some changes are envisaged to the street layout and public space. A Sydney Water Corporation (SWC) storm sewer culvert currently traverses the Berry Street and Walker Street sites and several options have been investigated to relocate the culvert outside the buildings footprint to reduce construction problems for the development.

Objectives

The key purpose of this report is to identify potential hydrological and hydraulic impacts associated with the proposed development and to recommend mitigation measures to be included in the detailed design. Some of the impacts considered include:

- Flow regime
- Water quality
- Drainage system capacity
- Flood impacts
- Peak flows
- Flood risk
- Climate change

Study Area Drainage Catchment

The existing drainage catchment extends out to McClaren Street and the Pacific Highway (approximately 15.8ha). It mainly comprises commercial buildings and a paved street network with varying slopes of 4.0% - 8.0%. The area is almost fully developed and it is unlikely that the impervious/pervious ratio will change in the future.

It is considered that a rainfall increase of 10% would provide an appropriate assessment of the effects of increases in rainfall due to climate change for the contributing proposed development catchment.

Water quality for the development will be maintained by providing Erosion and Sediment Controls during construction and Water Sensitive Design best practice during detailed design.

Flood Impacts

The existing development site currently has potential local street flooding issues in Denison, Spring and Little Spring Streets. Stormwater pits located in depressions along these streets may block or surcharge because of debris during a peak storm event and cause some nuisance flooding to driveways and shop entrances. Overland flows drain south down Denison and Little Spring Streets and then east to Walker Street. Provision

will be made in the development design to mitigate any flooding issues and ensure that there is no increase in street flooding.

The existing SWC culvert that traverses under the Berry and Walker Street sites seems to have ample capacity for the 100 year ARI flow from the contributing catchment based on calculated peak flows entering the system (refer to Section 2.5).

Several options have been considered to retain, adjust or relocate the existing storm sewer culvert where it passes through the development site. The preferred option is to re-route the culvert around the site along Spring Street. This route will retain the current capacity and accommodate all existing surface and lateral pipe connections.

2. Introduction

This report has been undertaken to satisfy the Director General's Environmental Assessment Requirements regarding the Drainage and Flooding component for this development.

The development is bound by Denison Street, Spring Street and Little Spring Street in North Sydney. This area currently consists of shops, offices and a basement car park. Below the car park an existing 1.2m x 1.2m covered concrete culvert crosses under the building from West to East. The culvert is owned by the Sydney Water Corporation.

The culvert location has impacts on the final design layout of the proposed development and the hydraulics of the existing stormwater system.

A separate stormwater investigation (Existing Stormwater Culvert Diversion Options Report Project J, North Sydney -2007 -refer to Appendix A) looks at various options available for Eastmark Holdings Pty Ltd to relocate, divert or adjust the existing stormwater culvert that currently traverses under their proposed future development.

Existing surrounding underground and surface street drainage should not be affected by the development proposal.

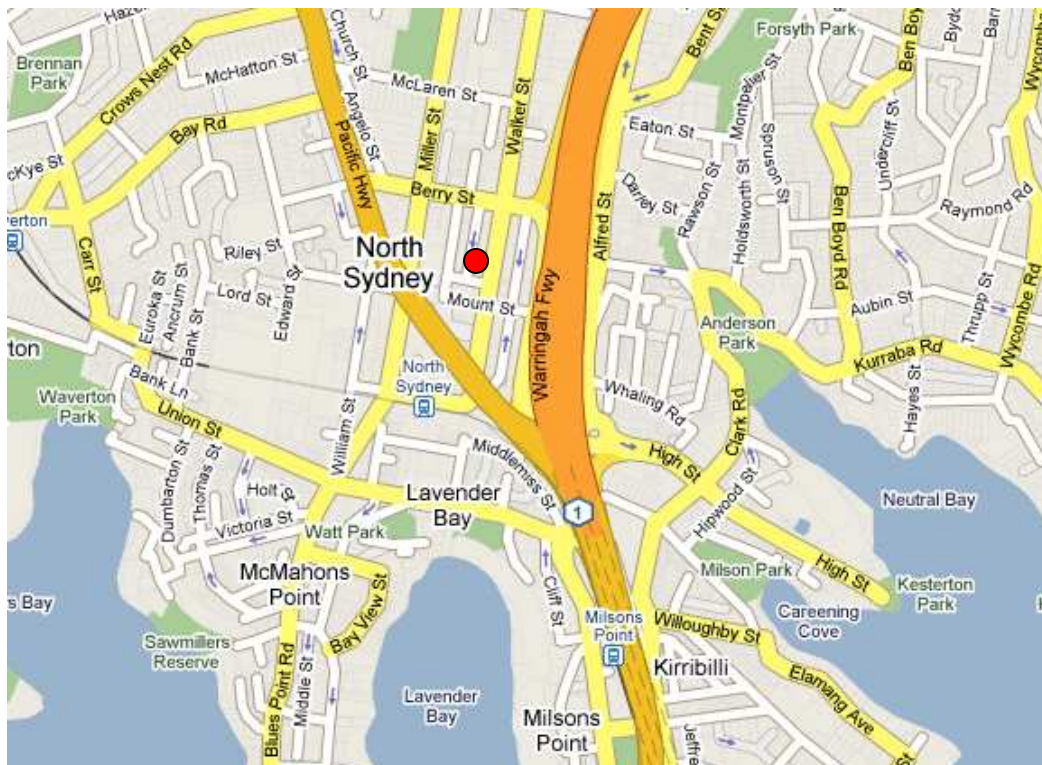


Figure 1 - Development Location Plan

2.1 The Study Scope and Objectives

To satisfy the compliance requirements of the Environmental Assessment the following key tasks have been undertaken:

- Collation and review of background information (previous studies, existing utilities, survey and mapping data) relevant to the project;
- Consultation with Government Agencies and stakeholders. This consultation was undertaken by Rice Daubney Architects and Connell Wagner;
- Identification of guiding principles for the assessment of hydrologic issues considering environmental, flood management and other requirements,
- Assessment of potential impacts and identification of mitigation measures;
- Consideration of climate changes relating to increased sea levels and rainfall intensity and;
- Consideration of Water Sensitive Urban Design best practise for the development to improve water quality.

2.2 Summary of the Compliance Requirements

Director-General's Requirements

Relevant Policies and Guidelines

- SEPP 55, 65, 66 Infrastructure 2007, BASIX 2004;
- Inner North Subregional Metropolitan Strategy (Draft);
- North Sydney LEP 1989, North Sydney LEP 2001 and North Sydney DCP 2002;
- Draft North Sydney LEP 2001 (Amendment No. 28) and;
- Nature and extent of any non-compliance with relevant environmental planning instruments, plans and guidelines and justification for any non-compliance.

Specific requirements for Flooding and Drainage

- Address drainage/flooding issues associated with the development site;
- Potential effects of climate change;
- Sea level rise and the increase in rainfall intensity;
- Drainage infrastructure and;
- Incorporate Water Sensitive Urban Design measures

3. Background Information

3.1 Existing Information

Information regarding the location of the storm sewer culvert traversing the proposed development was sourced from the Sydney Water Corporation (SWC) using the Dial Before You Dig service. Detailed design and as built drawings were obtained from the SWC plan room. These are included in the Appendix.

A desktop study has been completed by Connell Wagner to investigate several options regarding the relocation of the SWC culvert and is included in the Appendix.

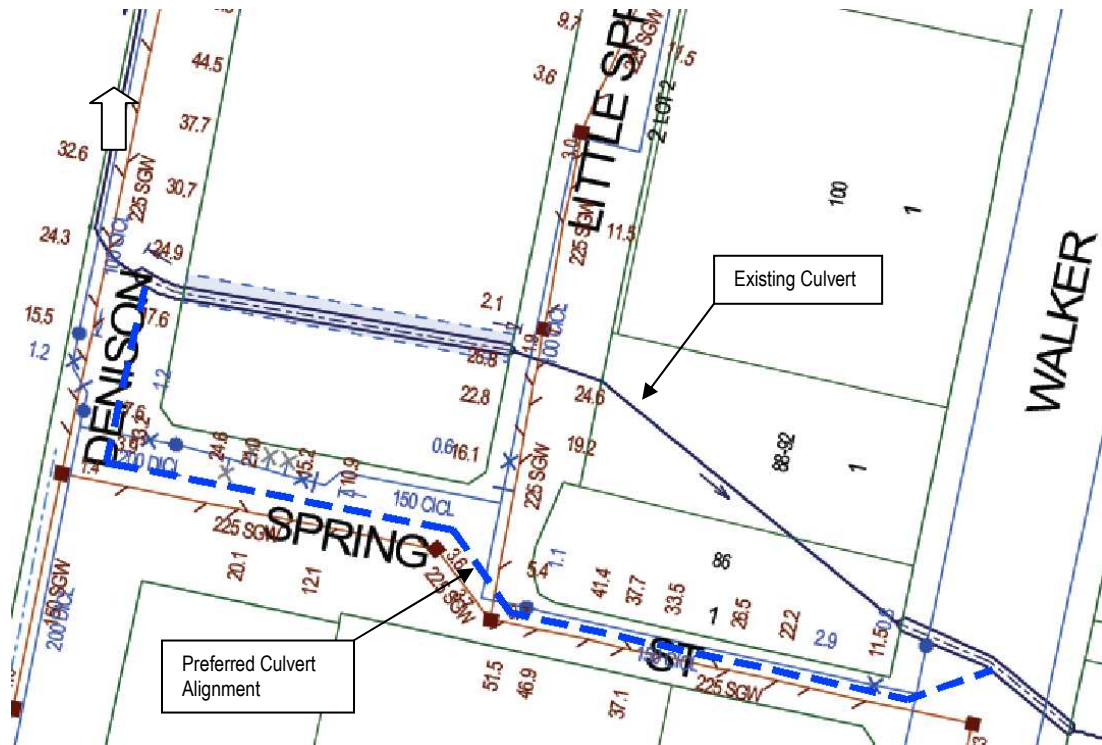


Figure 2 – Extract from the Sydney Water Corporation Plan Indicating Existing and Proposed Culvert Alignment

3.2 Available Survey and Mapping Data

Survey and mapping information was sourced using:

- Google Earth Professional;
- Land and Property Information NSW mapping resources;
- Department of Lands 2.0 metre digital contours
- North Sydney Council data base; and
- Frank M Mason and Co Pty Ltd survey

3.3 Relevant Guidelines

Relevant guidelines and standards that have been considered in this assessment include:

- Floodplain Development Manual, NSW Government (2005);
- Australian Rainfall and Runoff, Institute of Engineers Australia (1987) and;

- Draft Floodplain Risk Management Guideline – Practical Considerations of Climate Change, NSW Department of Environment and Climate Change (2007)
- Draft Sea Level Rise Policy Statement - NSW Department of Environment and Climate Change (2009)

3.4 Existing Site Conditions

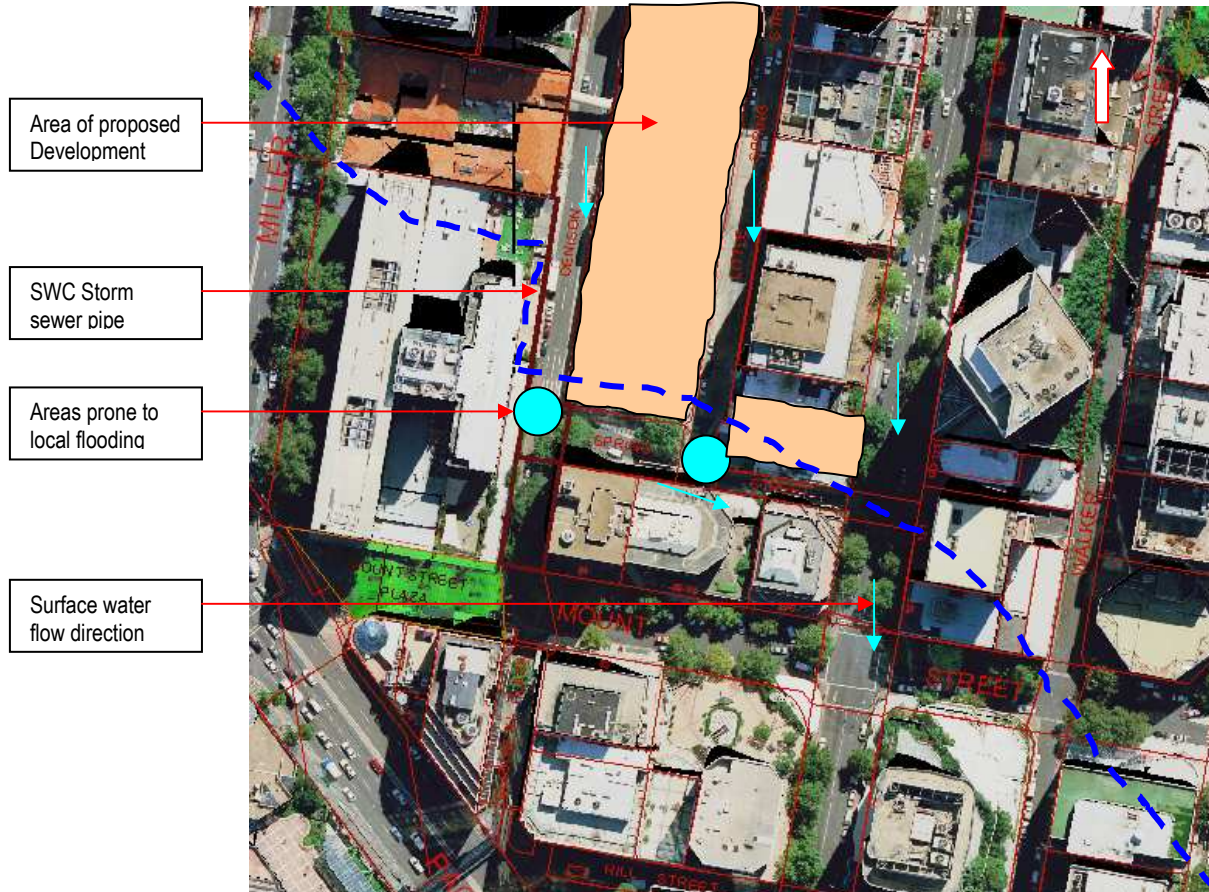


Figure 3 - Site Plan

The proposed development is surrounded by an existing paved street system with some streets planted with trees. Kerb and gutter with driveway entrances is typical for most of the streets and grated gully pits are spaced along the streets length to pick up surface drainage.

Generally the land falls from north to south with an approximate grade of between 4.0% - 8.0%.

Both Denison and Little Spring Streets have low points (RL 57.10 AHD and RL 54.10 AHD) where a below ground stormwater culvert (1.2m x 1.2m) traverses under the existing shopping centre car park.

For the existing condition if the surface pits block at the low points, Denison Street can inundate to approximately RL 57.40 AHD (300mm depth) and Little Spring Street to approximately RL 54.66 (560mm depth) before overflowing into Spring Street and then heading down to Walker Street. A driveway entrance, existing substation and corner shop entrance would be affected by local flooding.

Traffic calming devices (speed humps and raised pavement) constructed in Spring Street currently partially block and prevent overland flood flows from Denison and Little Spring Streets proceeding to Walker Street.

The existing culvert under the building basement is a Sydney Water Corporation asset and a 3.0m wide easement has been provided for it (refer to Appendix A – Existing Stormwater Culvert Options Report).

Utility services are found in all the streets surrounding the development. Services consist of sewer, water, Optus, Telstra, gas and electrical. Little Spring Street has major underground electrical infrastructure (refer to Appendix A – Existing Stormwater Culvert Options Report).

3.5 Drainage Catchment and Estimated Flows

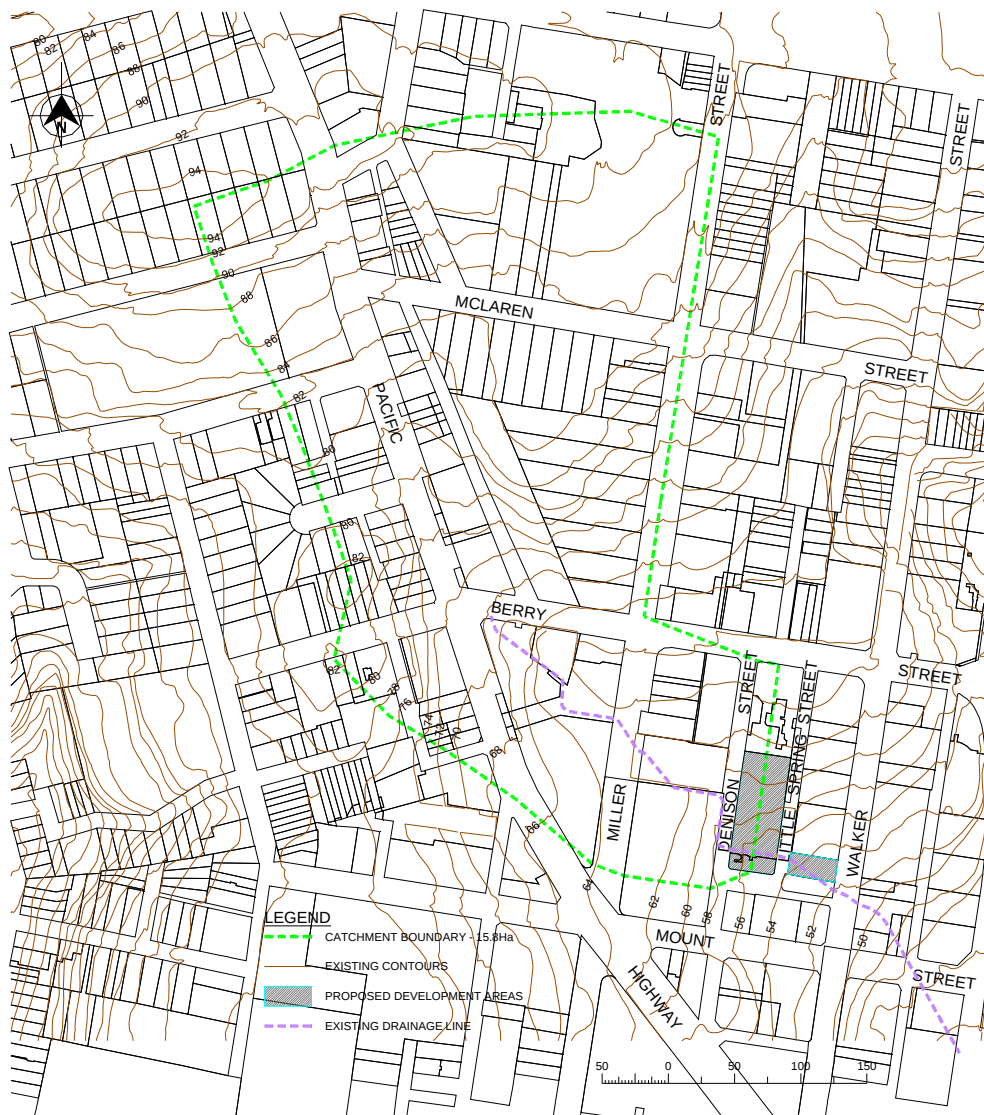


Figure 4 - Catchment Plan

The approximate contributing existing catchment area of 15.8ha to the culvert in Denison Street is shown on Figure 4. It has been based on contour information provided by North Sydney Council, Land Property Information NSW and a Site inspection. Impervious and pervious area percentages have been calculated from aerial photo maps (90% impervious, 10% pervious).

Calculations using a RAFTS model indicate approximate Peak Flows to the culvert at Denison Street for various storm events in Table 1. The critical storm duration time for the 2, 5 and 10 year ARI is 25 minutes and for the 20, 50 and 100 year ARI it is 90 minutes.

Table 1 – Peak ARI Flows

ARI (Years)	2	5	10	20	50	100
Peak Flow (m3/s)	5.1	6.8	7.7	9.1	10.1	11.3

3.6 Existing Culvert Flow Capacity

Based on information provided by Sydney Water Corporation the existing culvert between Denison and Little Spring Streets is a modification of an original 0.9m diameter pipe. The modified culvert is nominally sized 1.2m x 1.2m, comprising of 1.2m semicircular brick lined invert within a sandstone cutting with concrete block walls and a concrete covering slab at least 1.2m above the invert. (approximate internal dimensions are provided in Appendix A). At little spring street the culvert transitions to a 1.52m diameter conduit.

The flow capacity of the 1.2m x 1.2m culvert varies and is approximately between 15.0m³/s – 20.0m³/s. based on a longitudinal grade of 6.31%. This indicates that the existing culvert has ample capacity for a 100 year event providing there is no blockage.

3.7 Previous Flooding History

There are no known published records of any major flooding within the proposed development site, but nuisance flooding probably occurs in the existing area when street pits or stormwater pipes are blocked. This may cause inundation to some shop entrances, driveway entrances and low lying areas.

3.8 Flood Management Requirements

Investigation, analysis and design of drainage works should be consistent with the guiding principles of a number of floodplain management references, including:

- Floodplain Development Manual (FDF), NSW Government (2005) and;
- Australian Rainfall and Runoff, Institute of Engineers Australia (1987)

Guiding principles derived from these references include:

- That hydrologic and hydraulic assessments should be undertaken in accordance with current Australian practice;
- That consideration of blockage by debris is an integral part of a hydraulic assessment under major storm conditions and;
- Trunk drainage works (large capacity channels and/or culverts) should “carry and ... control the passage of floods up to some high magnitude, without overflowing and causing damage” (Ref FDF, p. 334) and “In addition to the ARI used for design, the performance of larger trunk drainage systems should be evaluated for extreme events such as probable maximum floods. This is to ensure that systems will fail in a predictable and relatively safe manner in such events, although significant damages should be expected” (Ref FDF, p. 297).

A 1% AEP (1 in 100 year) flood standard was adopted for the flood assessment and design of the underground culvert crossings. It is common practice to consider the full range of flood events up to and including the Probable Maximum Flood (PMF).

Blockage of the culvert by debris could significantly increase flood levels upstream and result in adverse impacts when overflow occurs. While culvert blockage is generally a recognised problem, historically, little practical guidance has been provided in regard to how much culvert blockage should be considered for design purposes. This is particularly difficult to quantify given the number of factors that can contribute to blockage including, upstream development, time since last significant event and the size of the waterway inlet. Based on past flooding in other catchments it has been shown that 100% blockage of culverts is possible in catchments having a significant amount and variety of potential sources of flood debris.

The catchment areas upstream of the proposed development are reasonably consistent in their degree of commercial built up environment with street tree planting and the potential for significant blockage due to debris is relatively low. Future upstream development is unlikely to increase the percentage impervious area to the contributing catchment due to the current density.

The proposed development has the potential to influence existing flow behaviour by diverting the stormwater culvert. This assessment has considered the impact this would have on flow behaviour in the wider catchment.

Street areas bounded by the development are to remain virtually the same or be improved so that any potential flooding would be no worse than the existing condition.

In summary the flood management requirements for the development would be to:

- Retain or improve existing surrounding street flow capacity
- Maintain or improve the existing flow characteristics of the underground culvert
- Provide on site detention if required to mitigate flows
- Reduce impervious hardstand areas (pervious paving, rain gardens, roof gardens etc).

3.9 Climate Change Impacts

Current reports indicate that climate change is likely to result in more frequent and more intense storms as well as sea level rises. Changes in flood behaviour due to climate change have the potential to increase the risk of flooding from backwater effects and increased storm intensity and duration times.

Due to the elevation and proximity of the proposed development from tidal influence it seems unlikely that increased seawater levels would have an impact on the development drainage system.

Studies undertaken by the CSIRO in conjunction with the Bureau of Meteorology (BOM) in 2007 investigated past and likely future changes to climate in NSW. The outcomes estimate that extreme rainfall (defined as a 1 in 40 year 1 day total rainfall event) would be likely to increase by up to 12% for the Sydney metropolitan catchments as well as the Hawkesbury-Nepean catchment by 2030.

The NSW Department of Environment and Climate Change (DECC) Draft Floodplain Risk Management Guideline – Practical Consideration of Climate Change recommends a sensitivity analysis for increases in rainfall of between 10% and 30%. However, given the research undertaken by CSIRO/BOM, it is considered that a rainfall increase of 10%

would provide an appropriate assessment of the effects of increases in rainfall due to climate change for the contributing proposed development catchment.

4. Proposed SWC Culvert Relocation Options

Several options have been investigated for the relocation/adjustment of the SWC culvert that traverses the development. These have been outlined in the Existing Stormwater Culvert Diversion Options Report, Project J, North Sydney -2007 (refer to Appendix A)

The desktop options that have been considered are:

- Leave the existing culvert where it is and build around it
- Lower and relocate the culvert under the building
- Divert and relocate the culvert within the property boundary
- Divert and relocate the culvert within the property boundary and re-route through the adjacent property
- Divert and relocate the culvert outside the property boundary
- Divert and relocate the culvert outside the property boundary and re-route through the adjacent property

The initial selection of the preferred options has been based on a matrix which examines construction risk, utility adjustments, cost, hydraulic performance, construction difficulty and relative indicative cost.

Construction issues and project timing dictate that the preferred option is to re-route the culvert down Denison Street and then along Spring Street towards Walker Street away from the proposed building works. The approximate culvert size would be a 1.5m diameter concrete pipe.

Confirmation is required during the detailed design stage when considering the hydraulic capacity, utility relocations, building structural requirements and connections to the downstream end of the existing culvert for determining the route.

5. Potential impacts from Proposed Works

5.1 Construction

Erosion and sedimentation from disturbed areas during construction will need to be controlled in accordance with “Managing Urban Stormwater Soils and Construction” (Landcom, 2004). For each component of work (such as the construction of the culvert, roads and buildings, etc) an Erosion and Sediment Control Plan or a Soil and Water Management Plan shall be prepared and incorporated into the Environmental Management Plan. The Environmental Management Plan shall include a monitoring program to assess the water quality downstream of the development site both during and after construction.

Measures to control erosion and sedimentation should include:

- Appropriate staging of works to minimise the extent of disturbance at any one time,
- Mitigation/control of onsite soil erosion through surface stabilisation and minimisation of slope length and gradient,
- Control of the movement of water onto, through, and off the site such as diversion drains to direct upstream runoff around the site and collection and treatment of runoff prior to discharge from the site.
- Protection to basement construction works and standby pumping facilities to treatment basins.

Treatment of runoff prior to discharge from the site shall include the provision of water quality treatment structures to minimise the dispersion of sediments into downstream watercourses. The exact location and sizing of water quality treatment structures will need to be finalized during the design stages. Design shall be in accordance with Section 6 of “Managing Urban Stormwater Soils and Construction” (Landcom, 2004).

Temporary by-pass measures will be required for any culvert diversion works. Pumping facilities will need to be put into place to direct stormwater flows downstream during the construction works. All works will require coordination so that construction occurs during favourable weather conditions and the risk of flooding is minimised.

5.2 Water Quality

Water quality is likely to improve from the proposed works when Water Sensitive Design measures have been implemented. Some of these measures are discussed in section 5.2 Stormwater Quality.

5.3 Flood Impacts

Basement Flooding

Basement flooding to car parking facilities and infrastructure from surface flooding is unlikely for this development. Any surface flows will be diverted along the existing street flow paths or captured by the drainage system.

Street or basement underground pipe failure could cause flooding of basements and temporary standby pumps will be provided for any inundated areas until repairs can be undertaken and completed.

Street Flooding

Potential existing nuisance flooding can occur at low points along Dennison and Little Spring Street which can cause water to enter driveway entrances and shops. There is scope to adjust the pavement/footpath levels and drainage at the intersection of Denison/Spring Streets and Spring/Little Spring Streets by removing the current traffic calming device. This would reduce the current inundation levels and improve conditions for entry and access locations. Additional drainage pits can also be constructed to reduce the risk of blockage occurring. Any adjustments would need to be coordinated with existing utilities in these areas.

The development at Walker Street and Berry Street will require ground floor flood protection for any entrances and sensitive infrastructure facing Little Spring Street and Denison Street. The current floor levels shown for the proposal are adequate providing a traffic calming device is removed and additional pits are provided at low point locations. Entry floor levels will be confirmed during the design development stage.

Drainage Capacity

The existing surface drainage system for the proposed development will be maintained. Any adjustments or relocation of the SWC culvert will be done so that the current capacity is maintained or improved. Further investigation is required during detailed design to determine the exact size and route for the culvert relocation/diversion. This includes coordination with the existing underground utilities.

Overflows from any proposed water harvesting storage tanks should be included in the hydraulic analysis of the drainage system to consider the worst case conditions.

Potential blockages from debris upstream of the development should be considered when designing the drainage system. A minimum 20% blockage factor should be allowed for.

Downstream Impacts

The proposed development surface flows to the downstream drainage system should remain the same. Relocation/adjustment of the SWC culvert could slightly reduce impacts downstream by designing the new drainage system to attenuate the existing flows. This will require further investigation during the detailed design stage of the development.

If water harvesting is adopted for the development, stormwater drainage flows can be reduced to the trunk system under normal conditions. This can only be effective if the water use for the buildings is managed appropriately and storage tanks have ample capacity to balance storage verses use.

6. Water Sensitive Urban Design Measures

6.1 Water Harvesting

Water harvesting options that can be implemented for the development site include:

- Rainwater tanks or underground storage capturing roof runoff;
- Underground storage direct from the stormwater piped system through a gross pollutant trap and;
- Underground storage from collected surface water through a sand filter medium (rain garden).

Anyone or all of the above systems could be used but specific areas must be targeted to utilise these fully.

Rainwater Storage Tanks Capturing Roof Runoff

The primary use for rainwater tank storage would be to supplement toilet flushing and garden drip irrigation.

Underground storage direct from piped system through gross pollutant trap

The interception and diversion of trunk stormwater drainage with an inline CDS or equivalent gross pollutant trap could divert the 1 year ARI flows to underground storage areas. Gross pollutant traps would remove quantities of oil, sediment and rubbish.

Underground storage from surface water through sand filter medium

Construction of rain gardens around the development perimeter would be used to collect surface water with subsoil filter pipes and direct it to underground storage areas. The sand filter treatment would ensure good water quality and reduced sediment load. A combination with the above systems could be incorporated.

At this stage the development has proposed 130,000 litres of storage from roof rainwater harvesting. This will be used to supplement landscape irrigation and toilet flushing. The overflow will connect into the stormwater system.

6.2 Stormwater Quality

Stormwater quality is related to adopting best management practises within the working site. Some of the relevant treatment measures that could be implemented for the development site include:

- Permeable paving
- Vegetated buffer strips
- Sand filters
- Rain water gardens
- Roof gardens
- Gutter guards and first flush systems
- Litter traps in stormwater pits
- Street sweeping
- Maintenance of pits and pipe systems (cleaning and flushing)
- Biofiltration systems
- Oil/grease separators
- In line gross pollutant traps

There is a variety of measures that can be taken on board and budget is the major consideration here. Water quality normally begins at the source so basic low cost items recommended would be litter traps in stormwater pits, rainwater gardens, planting of

buffer strips adjacent to roads, street sweeping and general maintenance of pits in urban type areas. Higher cost items that may be considered are gross pollutant traps intercepting major drainage lines.

7. References

- NSW Government
Floodplain Development Manual, 2005
- NSW Department of Environment and Climate Change
Draft Floodplain Risk Management Guideline – Practical Considerations of Climate Change,
2007
- CSIRO
Climate Change in the Sydney Metropolitan Catchments
NSW Government, 2007
- Australian Rainfall and Runoff, Institute of Engineers Australia (1987)
- Water Sensitive Urban Design – Basic Procedures for Source Control of Stormwater – A Handbook for Australian Practise, November 2004
- Draft Sea Level Rise Policy Statement - NSW Department of Environment and Climate Change (2009)

Appendix A

Existing Stormwater Culvert Diversions Option Report